LAHDEN AMMATTIKORKEAKOULU
Lahti University of Applied Sciences

STREAMING CONTENT IN REAL-TIME

The problems that providers confront with live streaming

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Tomi Tervo

Lahti University of Applied Sciences
Degree Programme in Business Information Technology

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ABSTRACT

This thesis examines the causes for problems when streaming content in real time over the Internet. Live streaming has become a popular choice for enjoying events in real-time. Customer discontent with their experiences with existing services is used as a motivation. Customer feedback plays a major role. Additionally, a founder of a company which provides live streaming services is interviewed in order to understand live streaming as a concept. Based on this information, live streaming processes are studied and potential problems are identified. The potential problems are eliminated one by one, exposing the most probable cause for problems in live streaming.

Key words: broadcast, live streaming, streaming

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TIIVISTELMÄ

Tässä kvalitatiivisessa tutkimuksessa tarkastellaan syitä, jotka tekevät tapahtumien reaaliaikaisesta lähettämisestä internetin välityksellä haasteellista. Asiakkaiden tyytymöttämiä kokemuksia kyseisiä palveluita kohtaan on käytetty motivaation lähteenä ja näiden asiakkaiden antama palaute on tässä tutkimusessa suuressa roolissa. Tutkimuksessa haastatellaan henkilöä joka on perustanut yhtiön, joka on keskittynyt tarjoamaan asiakkailleen suoria lähetyksiä internetin välityksellä. Näihin tietoihin perustuen tutkimuksessa tuodaan esille suoran internetlähetyksen prosesseja ja pyritään pureutumaan ongelmakohtiin. Mahdolliset ongelmakohdat eliminoidaan yksitellen, jolloin jäljelle jää kaikista todennäköisin syy, joka aiheuttaa ongelmia reaaliaikaisen suoratoiston kanssa.

Avainsanat: lähetys, reaaliaikainen suoratoisto, suoratoisto

CONTENTS

1 INTRODUCTION

> *"I'm bound to pay 240€ per year and in return I get this kind of crap? Even at the moment I'm not able to watch the game I paid for. I checked my facilities with your device testing tool and the results were good. If you keep ignoring my reclamations, I will contact the ombudsman!"*

This text has been taken from the E-mail conversation between a customer and a service provider. The customer was unhappy for the product itself as well for the customer service. The problem for the customer was an inability to view the content that was paid for. These unhappy customers have been common ever since the national ice-hockey (SM-Liiga) has been shown over the Internet. As an example, the previous provider, UrhoTV were valued among the least respected brands in the world by Finnish people. (Markkinointi&Mainonta, 2010)

The current provider, Nelonen Media was marketing heavily their new product called "Ruutu+" on summer 2013. Ruutu+ is a service that provides video content online. With the new product, the customer was promised to be able to watch every single SM-Liiga match in real time with high-definition quality. On top of that, the matches were promised to be watched also afterwards at any time. This research concentrates on Ruutu+ and more accordingly to its live streaming concerning SM-Liiga matches. (Nelonen Media, 2013)

SM-Liiga is the most popular national sport in Finland. Therefore it arises great deal of discussion among the fans. One of the most popular places to discuss about ice-hockey in Internet is online magazine called "Jatkoaika.com". The users of Ruutu+ have been sharing their experiments constantly in the forums of Jatkoaika. Therefore that forum is an excellent location to gather information how well Ruutu+ has managed with their promises. (Suomikiekko, 2014)

The first official SM-Liiga live broadcasts from Ruutu+ started on 12th of September in 2013. During that day, two matches were broadcasted simultaneously. During same day, the product got plenty of criticism. Here are quoted some of the experiences:

> *"1) Picture quality. Channel manager Jorma Paakkari talked during intermission how whole product is HD quality. This is not true. Picture is fussy that is scaled SD quality. This, if something, is misleading marketing.*
>
> *2) Functionality. Issues have been spotted on every broadcast methods. Error message "Type Error #1009" ruined the evening of many. For me, the product worked well first two periods. During third period the broadcast stopped twice."*
>
> *"The whole broadcast was a complete faceplant. I had all the problems that have been mentioned here already. The question is, how can I get rid of this product? How large army of lawyers is needed?"*
>
> *"People have been sent into the moon but these clowns can't get one game working."*

Most of the customers also declared that they haven't had similar problems with the other providers and confirmed that their facilities exceed the requirements. (Jatkoaika, 2013)

There is quite severe incongruity between the customer experiences and what was promised by the Nelonen Media. This research aims to seek what causes the problems.

2 METHODOLOGY

This chapter describes the research and the means of carrying the research through.

2.1 Research problem

The research is a constructive study with the goal of finding the reason what causes the inconqruity between the promises of Ruutu+ and the customer experience.

There are several questions from the customers that the providers of live streaming have not been able to answer. This study raises some questions and providers anwers at the end.

The study seeks answers to the following questions:

- What causes the problems in live streaming?
- What is the responsibility of end-user?

The research aims to understand the phenomenon and the data is examined in detail. Therefore qualitative research methods are chosen to be suitable approach for this study. The research is an inductive study since it aims to create a theory on live streaming issues.

2.2 Implementation

Customer experiences have been studied constantly since the first official SM-Liiga broadcast from Ruutu+. For the comparison, customer experiences have been studied from other providers as well. Other providers are MTV Katsomo and Viaplay. Katsomo broadcasts ice-hockey world championships and Viaplay broadcasts National Hockey League (NHL). These studies have given an excellent understanding of the phenomenon.

Katsomo and Viaplay give the same promises of their product as does Ruutu+. However, the first mentioned providers have considerably better customer

experiences. Many unpleasant Ruutu+ customers have often marveled how the content of the other providers works just fine.

The prevalent phenomenon strongly suggests that the SM-Liiga is the only product with the live streaming issues. This assumption gives an allusion that the problem is local and isolated. Therefore the answers were not searched from the existing literature, but information was gathered from company that provides live streaming services. The first choice for this particular company was Nelonen Media itself. However, the attempts to approach were counterproductive. Therefore the next best alternative was interviewed for this research. During the the interview the content was written on the paper.

The research was carried through with the help of the Ruutu+ customers as well. Some of the customers provided help knowingly by delivering their E-mail conversations between them and the provider. On the other hand, some of the customers helped unbeknownst by sharing in detail their experiences to be commonly examined. This data has been examined to detect which end user devices and settings award the best viewing experience.

3 PHENOMENON

In this chapter is described the current situation of streaming in Finland. The research made by Sonera has been used as an instrumental. In this particular research, live streaming is not examined separately, but is part of the streaming statistics.

3.1 Internet customs

On 17th of June 2013, Sonera published a research of Finnish Internet usage and customs. Sonera is a telephone company that operates mainly in Sweden and Finland, but has also operations in Europe and Asia as well. In Finland, Sonera is the second largest operator in every aspect, when counting mobile network, TV-network and Internet. For example, as an Internet provider, Sonera holds 30% of market share, which means 501 000 customers. (TeliaSonera, 2012)

The research was answered by 2 767 Internet users in Finland. It reveals that 71% of Finnish Internet users watch video content online. Furthermore, 77% of the users credit Internet to be the most important technical implement in the household. (Sonera, 2013)

The same research also displays that the popularity of pay-per-view content is increasing. During year 2012 the amount was 33%, which merged into 36% during next year.

> *”The popularity of online videos and pay-per-view content in Finland is higher than ever.”*

These are the words of the research director of this research.

3.2 Observation

The popularity of pay-per-view content has increased three percentage points from 2012 to 2013. The increment has been explained by the development of the provided content. It also shows that the customers are responding for the supply.

This indicates that in the future the supply will keep increasing and so do the amount of customers and the usage of particular service.

71% of Finnish Internet users watch video content online and therefore uses streaming technology. This result confirms that streaming performs in major part of Finnish Internet usage and customs. Streaming has never been this popular in Finland.

4 LIVE STREAMING

Live streaming is a manner of transferring multimedia files over the internet. Therefore live streaming requires internet connection from the broadcaster as from the receiver. While both, broadcaster and receiver are connected to internet, multimedia files can be broadcasted and received. The broadcasting begins immediately and the material mustn't be downloaded first. However, the broadcast ends if either the broadcaster or receiver is not connected to the internet.

While live streaming, the material that is broadcasted happens in real-time. One of the most common examples of live streaming is the usage of web camera.

4.1 Environment

In order to understand what happens in live streaming, a founder (Person A) of local live streaming company was interviewed. The company that Person A founded offers live streaming services and solutions to its customers. The company was established in summer 2010. After its establishment, the company has streamed three World Championship events. The company has also streamed pay-per-view content, including official ice-hockey matches. The record of highest amount of concurrent viewers is over 11 000. Therefore it is justifiable to assume that Person A will hold valuable information concerning this research. Person A was also eager to help understand the processes of live streaming and offer his knowledge and opinion about the researched issue.

Figure 1 shows the processes of live streaming. The picture was made by based of the interview of Person A.

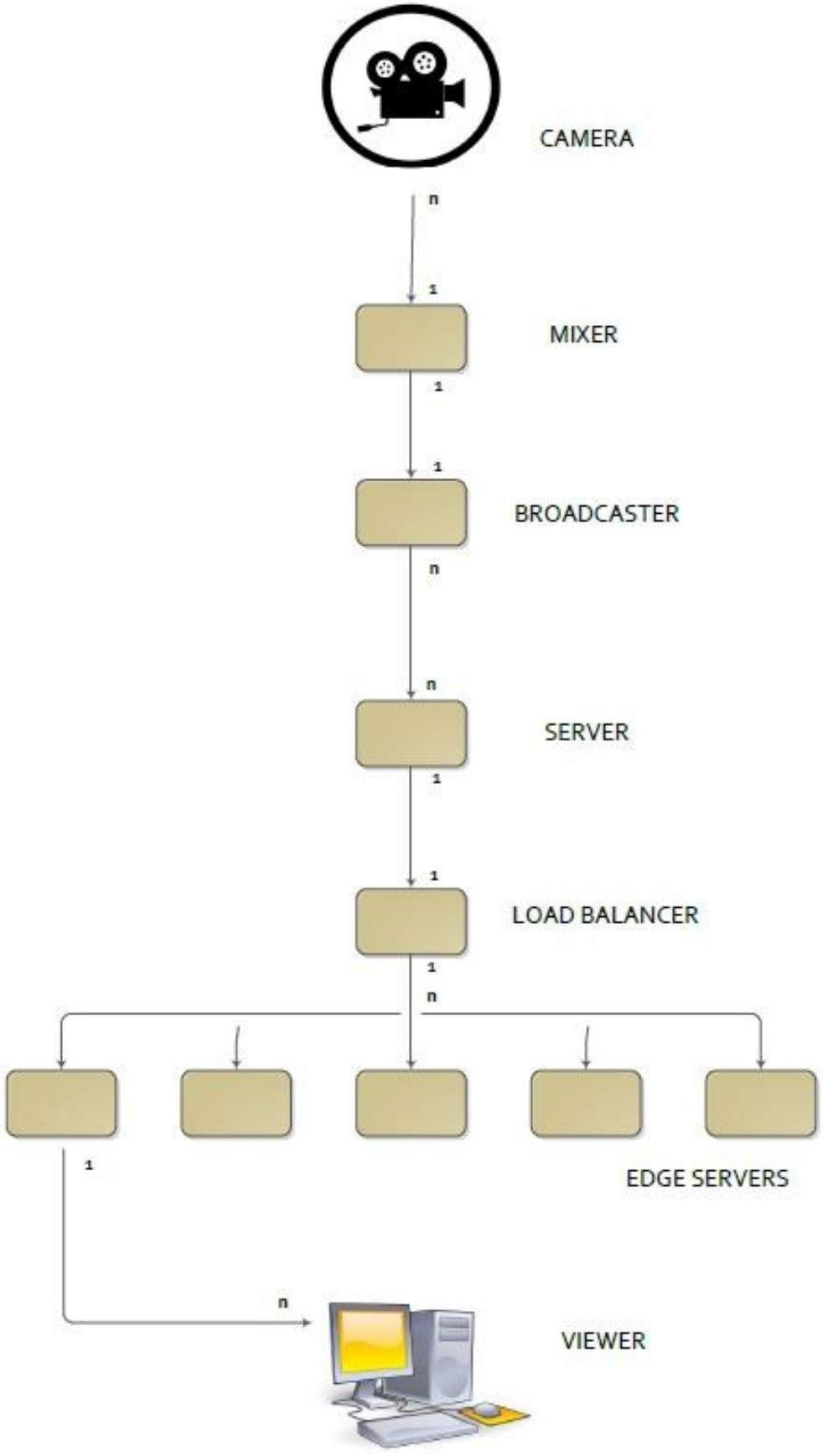

Figure 1 - Processes of live streaming

4.1.1 Video capturing

This chapter explains following processes from Picture 1: “camera, mixer and broadcaster”.

Live streaming begins by capturing video. This video is sent to the mixer in real time. Mixer can have several cameras as an input and it is the mixer that decides which video footage will be sent forward into broadcaster. The mixer can be bypassed if there is only one camera and therefore only one video signal, as in the web-camera example that was used earlier. However, the cases this research studies has several cameras and the mixer is required process. Video signals also contains audio signal.

The broadcaster has one mixer and receives one video signal from the mixer. Broadcaster also sends one video signal into server.

These are the processes that make the difference between live streaming and streaming or video-on-demand (VOD) as it is often named. With VOD the material is already in the server, whereas with live streaming the data is provided constantly in real-time.

4.1.2 Server

The relation between server and broadcaster is many to many. Server can receive several video signals from different broadcasters and one broadcaster can send video signlas into several servers. One server has a unique address that seperates it from other servers. Video signal, at this point of process addressed as a stream, has a unique stream ID that seperates one stream from the others.

Broadcaster delivers the streams into servers via Internet. Therefore broadcaster must be connected into Internet. The upload speed of the Internet that is connected to the broadcaster gives the limit of the stream quality that can be sent forward. Based on Person A’s experience, the amount that is sent should be half of the upload capacity. The reason for this is the variety of the Internet connection strength. For an example, if the the delivered stream uses the whole upload

capacity and there is a drop in the upload speed, the stream will stutter since the broadcaster can't deliver as much data as it should.

4.1.3 Load balancer and edge servers

There is one load balancer addressed to each server and on the other hand, each server has one load balancer. Load balancer is a distributor of the stream that has one to many edge servers. Edge servers have one load balancer.

The edge servers are often located separately from each other. The reason for this is to diminish the distance between the edge server and the viewer. Therefore the load balancer addresses a stream to the edge server that is the closest of the viewer. The shorter the distance between a viewer and an edge server, the shorter is the respond time and higher the frame rate. Although in the case of this research the viewers are located in Finland and therefore the distance doesn't act in major role.

Load balancer also allows the usage of minimum amount of edge servers. This makes streaming more cost effective since unnecessary edge servers can remain closed. The load balancer can be told to open new edge server when the edge server in use reaches certain amount of its capacity. Edge server's capacity is defined by the maximum amount of concurrent viewers.

4.1.4 Viewer

Viewer receives the data from one edge server. The edge server can be selected by the location of the viewer or by the amount of concurrent viewers. The edge server has one to many viewers.

The viewer must have at least the same capacity to receive data that is the amount what the broadcaster delivers. Again, if the viewers Internet download speed is exactly the same what the broadcaster delivers, there is a possibility to experience stutter because of variety in Internet strength. This is the reason why providers, such as Ruutu+ states the minimum recuirement of the Internet speed to be higher than what is used in the delivery.

By now the whole process from camera to the viewer has been examined. In order to have succesfull viewing experience, the facilities of the viewer play in major role. When questioned Person A's opinion where the problem exists for Ruutu+ in the live streaming processes, the answer is that in most of the cases the problem is at the viewers end.

4.2 Technique

The most common technique for live streaming is Real Time Messaging Protocol (RTMP). This protocol was developed by Macromedia, which is currently owned by Adobe. The main concept of RTMP is to stream video, audio and data over the Internet, between a Flash player and a server. Here lies one of the disadvantages of RTMP, since Flash is not supported by every platform, for an example iPhone Operating System (iOS). This means that in order to stream to every possible platform, different protocol must be used alongside RTMP. This involves the usage of completely separate server, so the same data must be send twice to the own servers. Having two servers instead of one makes the streaming cost more and also uses more bandwidth. (Anon., ei pvm)

Furthermore, RTMP doesn't work in HTML5. World Wide Web Consortium (W3C) has proposed a plan to release stable HTML5 recommendation by the end of 2014. Therefore newer HTTP streaming protocols, such as Apple's HTTP Live Streaming (HLS) that supports HTML5, is likely going replace the RTMP over the coming years. (Berjon, 2013)

However, RTMP offers some key features that make it popular choice when doing broadcasts. Some of these features are useful when streaming videos on demand. One of these features is the possibility to jump any part of the video without waiting it to be downloaded first. This is extremely useful for video files which length is over 10 minutes, because otherwise the viewer would have to download the whole file first and this would be time consuming. Considering this feature, RTMP is effective technique for live streaming, if the event is recorded and later shown as video on demand. (Anon., ei pvm)

4.2.1 Dynamic streaming

Yet, the considerable reason to use RTMP for live streaming is the possibility for dynamic streaming. Dynamic streaming requires that multiple streams are delivered with different bitrates. For an example, there could be three different streams broadcasted, where one uses low bitrate, the other uses medium bitrate and the last one uses high bitrate. The media player that is assigned to show these streams can measure the viewer's capability to receive data. In other words, it measures the viewer's internet speed and chooses the best stream accordingly. When the viewer has high internet speed, the player displays the stream that has high bitrate. This feature maximizes the number of viewers without diminishing the viewing experience. It also helps with the dropping Internet connection for those who are able to use or watch the stream that doesn't use the lowest bitrate. In that case, the player would dynamically select the lower bitrate stream instead of causing stutter.

Dynamic streaming is fairly new phenomenon in Finland. Urho TV is a television company that streamed live SM-Liiga matches between 2009 and 2013. They never used dynamic streaming. Instead of that, they used bitrate selection plug-in, which allows the viewer to choose the desired stream. The benefits of bitrate selection plug-in are rather limited when comparing to dynamic streaming. In the case where viewer's equipment is not powerful enough to play high quality video, but the internet speed is high enough, dynamic streaming automatically choose the high quality video. This would be problematic and the video wouldn't play as it should. Furthermore, with bitrate selection plug-in viewer can prioritize one stream over another, when multiple streams are played. For an example, two streams are played simultaneously and the other stream is holding the higher importance than the other. In this particular case, the viewer can choose to have high quality for the more important stream and low quality for the less interested stream. Dynamic streaming wouldn't prioritize, so both streams would have medium quality. However, this example only acts when having limited resources to play two streams with high quality.

5 RESEARCH

In this chapter the gathered data is explained. Parts of the Figure 1 are used as an instrumental.

5.1 Potential problems

The problem for the customers has been the inability to view the content that is delivered in real-time. Therefore the problem is somewhere between the camera and the viewer.

5.1.1 Viewer

> *"Customer service has not replied anything for me, but I know what they would say. The problem is not in our end and you should buy new computer and change the Internet operator. Also remember to turn off the power of your router for 30 seconds. "*

This comment has been posted to the forums of Jatkoaika on 26th of the April 2014. During the same day was the last official SM-Liiga live broadcast from Ruutu+ and completed the first year of their five-year-contract. This comment greatly suggests that Nelonen Media has been accusing the viewer for the problems during the first year. Also when Person A was interviewed and personal opinion of the problem was asked, the answer was a viewer. (Jatkoaika, 2014)

However, the aspect that the viewer is the complication during the process has not solved the initial problem during the first year. Therefore this research is based on an assumption that the problem is located somewhere else.

5.1.2 Internet connection

A potential problem is the insufficient Internet connection between the server and the broadcaster. Figure 2 illustrates the location with an exclamation mark.

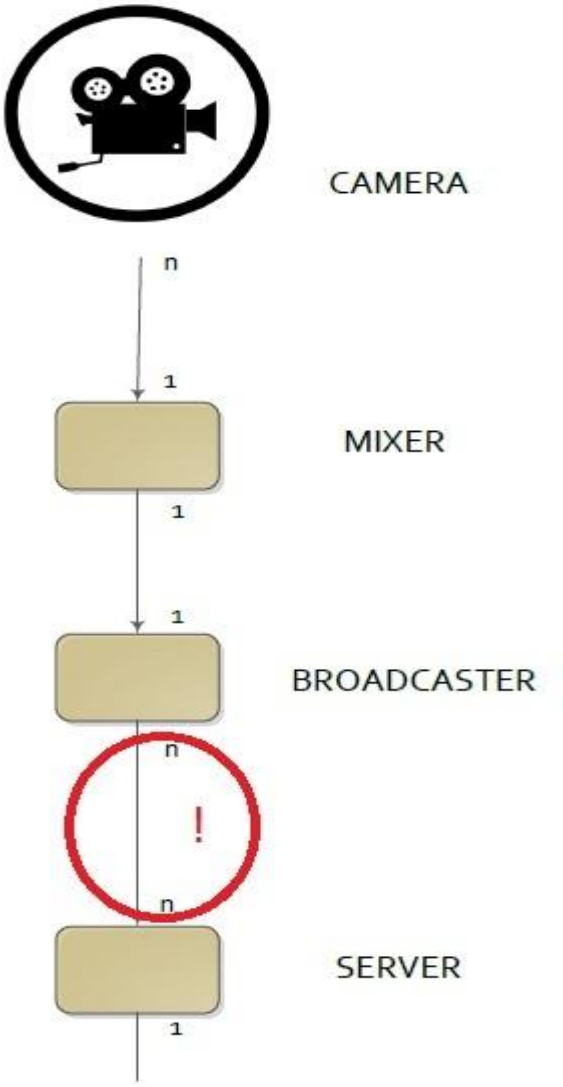

Figure 2 - The location of potential problem

Ruutu+ uses dynamic streaming. This signifies that the broadcaster must deliver several separate streams with different qualities. Based on the information given by Nelonen Media, the qualities are 360p (low), 480p (medium) and 720p (high-definiton). These three different qualities require total bitrate of 4000 Kbps. In other words, to be able to deliver these three streams from the broadcaster, the Internet upload speed must be at least 4 Mbps. Also when kept in mind the safety regulations mentioned by the Person A, the upload speed should be double of the minimum requirements. In this case, the Internet upload speed should be 8 Mbps. Lower upload speed could cause a situation where the momentary upload speed is

not enough to deliver the required data for all three streams. In this case the viewer will not be able to receive the required data for flawless viewing experience. (Nelonen media, 2013) (Livestream, 2013)

5.1.3 Server and route capacity

Another potential problem is the lowly capacity of the edge servers. A related problem to this is the low capacity on the routes that leads into the edge servers. Figure 3 illustates these locations with an exclamation mark. The upper exclamation mark indicates the route and the lower indicates the totality of edge servers.

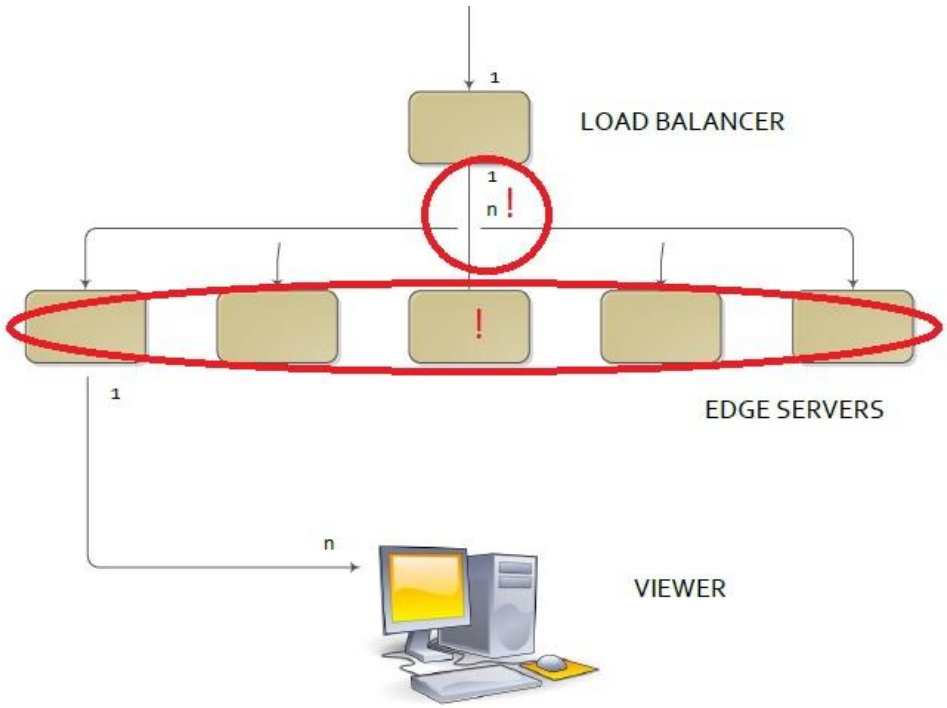

Figure 3 - The locations of potential problems

In order to use the Ruutu+ services, the customer must log in into the service. When customer logs in, the request is sent to the edge server. The edge server capacity defines how many concurrent requests can be dealt with. When this capacity is reached, no more requests can be received. In this case, load balancer

directs the upcoming reguests into the new edge server. In case all the edge servers have reached their maximum capacity, the upcoming requests will not be answered. This will cause the inability to operate the web page.

Whereas the edge server has its capacity, also the route that leads into the servers has a maximum capacity how many concurrent requests can be delivered. In case the capacity is reached, upcoming requests will not be delivered. This will also cause the inability to operate the web page.

6 CONCLUSION

This chapter aims to create a theory what of potential problems is the actual problem.

6.1 Internet connection

The locations where the video capturing processes, including the delivery from the broadcaster into the server, takes place are indoor ice rinks. Most of these indoor ice rinks are built well before the age of the Internet. Stereotypically it suggests that when the Intenet arrived, the required installments were made that enabled these ice rinks to connect into the world wide web. However, since the Internet connection is not top priority in these locations, the danger exists that required renovations have not been done in order to update the upload speed to meet the modern day requirements.

An employee (Person B) of one of the broadcast revenues was contacted. Person B is responsible of the maintance in that particular location. One of the tasks is to maintain and look over the Internet connection. Person B informed that the current Internet connection is the fastest option that is possible to obtain, offering upload speed of 5 Mbps.

The minimum requirement for the three streams having different bitrate is upload speed of 4 Mbps. The revenues' upload speed exceeds the minimum requirements. However, it is still on the danger zone based by Person A's experience and therefore is exposed to the variation of the strength of the Internet.

Such a small buffer between the minimum requirements and actual Internet upload speed can cause delivery problems. Unless, the delivery from the broadcaster to the server is done somewhere else. In order to ensure this, the chief executive officer (Person C) of the company that is responsible of the video capturing at the particular revenue was interviewed.

Person C confirmed that the captured video is not delivered from their broadcaster to the server. The video signal from their broadcaster is delivered to the company that is located in Helsinki. Person C also mentioned that same protocol is obeyed

in every other revenue as well. Therefore all the live content is delivered to server from one place that operates in Helsinki. The moderate internet upload speeds at the indoor ice rinks are not the reasons that cause problems in live streaming.

6.2 Server and route capacity

Live streaming sets the edge servers and routes in under heavy stress. The reason for this is the amount of concurrent users. The phenomenon is especially fierce with the Ruutu+, since all the SM-Liiga matches start at the same time. Therefore all the customers attempts to log in into the service at the same time.

Many Ruutu+ customers have marveled how massive streaming operators such as Netflix and YouTube can be used at any time without problems. This phenomenon would strongly suggest that the problem is not at the viewer's facilities, but on the edge servers or routes. Since Netflix and YouTube are not based on live streaming, those providers are unlikely to receive such an enormous spikes on the amount of concurrent users.

Ruutu+ requires a Flash player from the desktop computers. This ensures that the customers who operate desktop computers will be using different edge servers than the customers who operate with iOS. (Nelonen media, 2013)

In order to understand better the behavior of the edge servers and the routes, customer satisfaction was examined. The data was gathered from the formus of Jatkoaika. Those were chosen into the statistics who declared clearly the viewing experience and the platform that were operated. The viewing experience was divided into two sections, into satisfied and unsatisfied. The operated platforms were also divided into two sections, where desktop and laptop computers were in one section and iOS devices (iPhone and iPad) in other section. Androids were not included because of the low amount of shared experiences. The data consist of 65 experiences. (Jatkoaika, 2013)

Chart 1 indicates the distribution in the customer satisfaction, when all the experiences were studied.

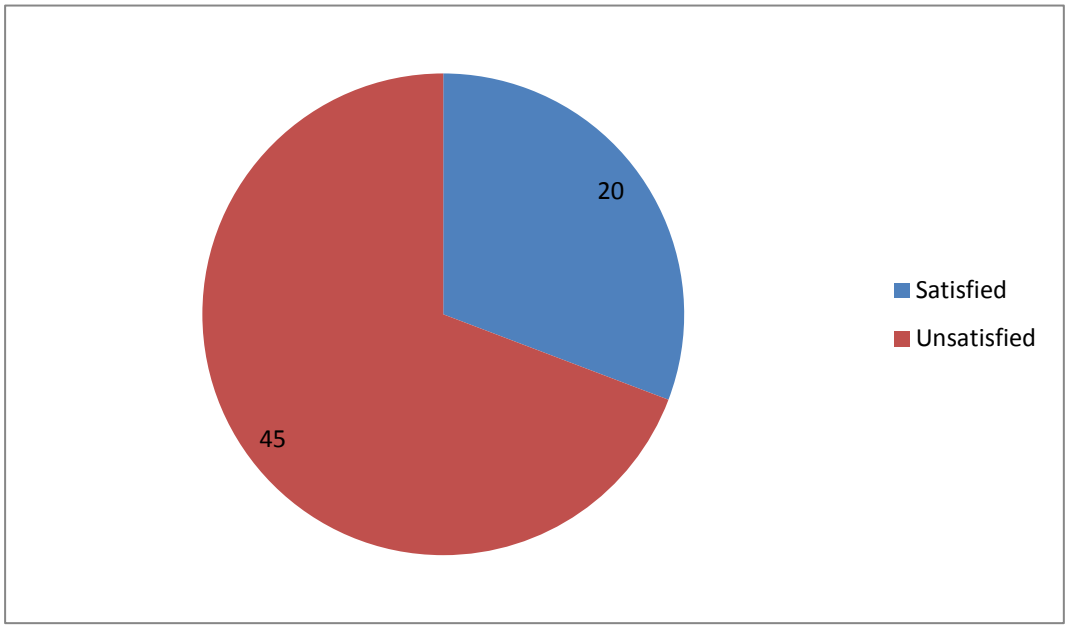

Chart 1 – Customer satisfaction

Out of the 65 experiences, 45 were unsatisfied. However, the assumption can't be made that this result correlates the situation when the entire customer base of Ruutu+ is taken into account. Often satisfied customers don't have the need to comment their experiences whereas unsatisfied customers wish to share the bad experience.

Chart 2 indicates the distribution between operated platforms.

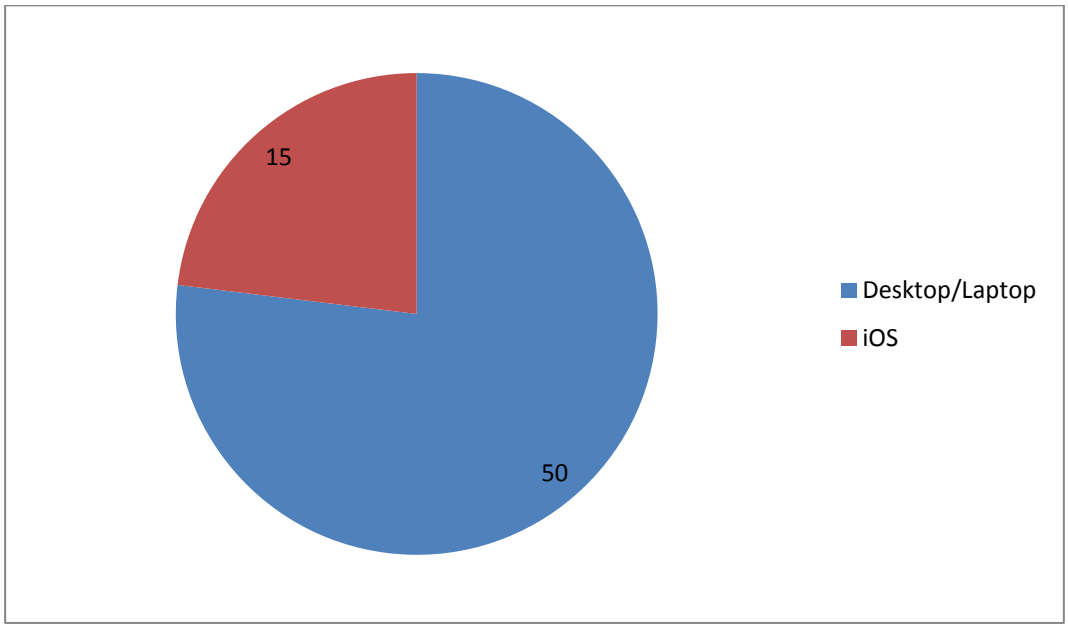

Chart 2 – Operated platforms

Here can be seen that desktop and laptop computers are far more operated platforms when compared into iOS devices. Therefore the capacity of edge servers and routes must also be much higher for the computers.

Chart 3 indicates the customer satisfaction, when desktop and laptop computers are operated. Chart 4 indicates the customer satisfaction, when iOS devices are operated.

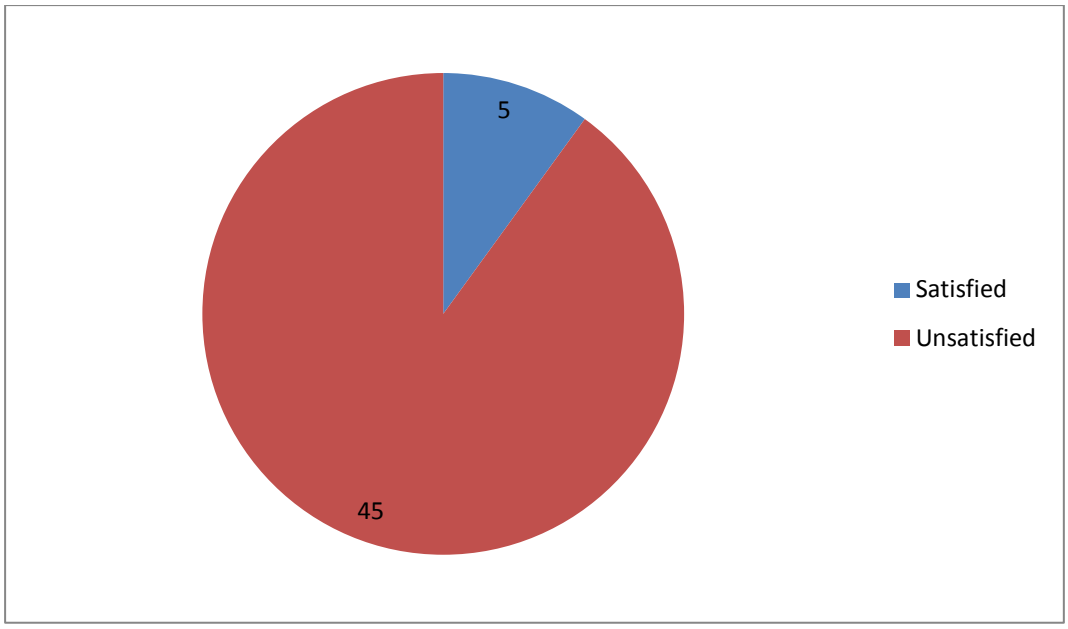

Chart 3 – Customer satisfaction of computer users

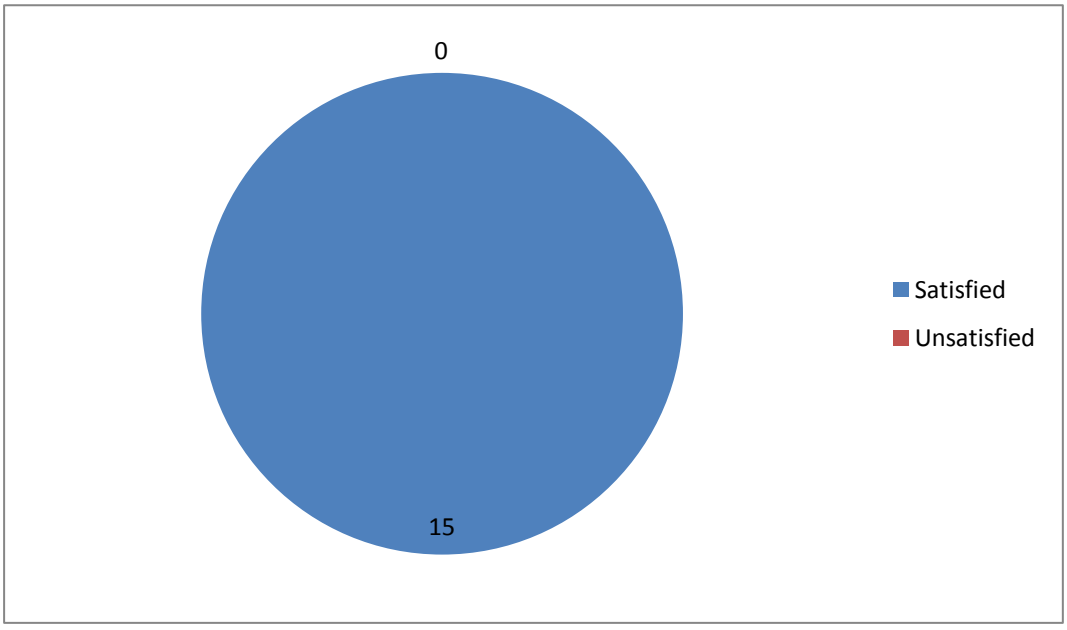

Chart 4 – Customer satisfaction of iOS users

Every tenth customer was satisfied, when operating with desktop and laptop computers. Again, the assumption can't be made that this correlates to the total amount of Ruutu+ customers since the unsatisfied customers are more likely to share their experiences. However, the difference in customer's satisfaction is

massive between the operators of computers and iOS devices. Every single iOS operator was satisfied for the product. Since the customer experiences of iOS operators were so satisfied, the distribution between operators (Chart 2) might be even bigger when taking into account the whole customer base of Ruutu+.

Chart 1 indigates that there are more customers operating with the desktop and laptop computers than there are customers operating with iOS devices. Chart 2 indicates that customers who are operating with computers are mostly unsatisfied whereas Chart 3 indicates that there are no untasfied customers among the operators of iOS devices. These results strongly suggest that there are problems with the capacity of edge servers or routes.

7 SUMMARY

In this chapter the entire research is summarized and also the research questions are answered.

7.1 Results

In this research two potential problems were studied that may cause the inability for the customer to view the content as it should be shown. One of the potential problems was insufficient Internet upload speed at the venue where broadcasting takes place. However, the study revealed that the insufficient Internet upload speed of the venue is not the potential problem.

Even the problem doesn't exist at the venue; it doesn't determine that the problem is completely excluded. As Person C explained, the video signal from their broadcaster is delivered to the other company that uploads it to the server. The protocol is same at every venue; therefore the company that takes care of the uploading can receive several video signals from different venues.

In SM-Liiga there are 14 sport clubs. This means there can be seven concurrent matches which lead to the situation where seven videosignals must be delivered into the server at the same time. Earlier it was discovered that the dynamic streaming with the qualities that Ruutu+ uses requires 4 Mbps Internet upload speed. However, delivering seven seperate dynamic streams into the server requires seven times faster upload speed. The required upload speed in this case is 28 Mbps. When adding the safety protocols mentioned by Person A, the Internet upload speed at the location where dynamic streams are delivered into the server should be 56 Mbps.

The required upload speed is rather high. However, the earlier mentioned telephone company Sonera can offer to its customers Internet connection with the upload speed of 100 Mbps. In the case where a company can receive seven concurrent video signals from different locations, it is justifiable to assume that the location of the company has been renowated to be able to update its connections to meet the modern day requirements. Therefore the Internet

connection is not seen as a problem in this case and is excluded from this research. (Sonera, 2014)

The studies of customer satisfaction suggest that the live streaming problems of Ruutu+ are caused by the lack of the capacity in the edge servers or in the routes.

In order to view the live content of SM-Liiga from Ruutu+, the customer must first register to the web page. After registration, the customer must buy the rights that allow the access into the live content. Customer can't buy the rights for a single broadcast. The rights are bought either for one day or for one month. (Nelonen Media, 2014)

Since there is not a possibility to buy the rights for one separate content only, the total amount of viewers should be well known beforehands. In the other words, only the customers that have active account are the possible viewers and therefore the only ones that can stress the edge servers and the routes.

Each edge server has a capacity of the maximum amount of concurrent viewers. This capacity is known and since the amount of active customers is also known, the amount of needed edge servers can be concluded. Therefore the lack in edge server´s capacity seems unlikely, since new edge servers can be added or activated accordingly. Based on these arguments, the theory of limited capacity of the edge servers is excluded from this research.

7.1.1 Problems in live streaming

The known amount of active customers enables to react to the need of capacity changes. New edge servers can be activaded to respond the the amount of viewers. However, the capacity of the routes that lead into the edge servers must be increased in same respect. This is a potential problem. Even if there is enough of edge server capacity, the viewer's request won't reach the edge server if the routes have become obstructed.

Buildings that hold high capacity of people can be used as an example. In this particular example are used a football stadium. The stadium itself represents an edge server. The gate that leads to the stadium represents a route that leads to an

edge server. Exactly like in the real case, people starts moving into the stadium before the event. The stadium is expected to be full and the capacity is increased. However, only one gate still remains that leads into the stadium. The event begins, but majority of the people are still at the gate waiting for their turn to get in. The people at the gate become furious, since this is not what they paid for. The first ones who arrived at the stadium got in without problems and were able to enjoy of the event. There is also another stadium next to the first stadium and it is holding the same event. However, there are not many people attempting to approarch this stadium and everyone can get past the gate without any problems.

The example used above correspond the studied phenomenon and user experiences accurately. Therefore this research suggests that the problems in live streaming are caused by the inadequate capacity of the routes that lead into the edge servers.

7.1.2 Responsibility of end-user

Before registering or buying the rights for a live content, the user should ensure to exceed the minimum requirements that are set by the provider. Usually customer should be aware of the Internet download speed and the power of the central processing unit (CPU). The usage of dynamic streaming diminishes the need of viewer's facilities, since the lighter option is provided.

Whenever attempting to view live content, it is recommendable to log in into the service well before the event itself starts. This will diminish the problems that are caused by the inadequate capacity of the routes.

7.2 Reliability and validity

During this research the data that concerns the basic processes of live streaming was gathered only by interviewing one person. This leaves room for the different understandings how the processes are executed. This research follows accurately the process that was presented. Therefore with different understanding the outcome could have also been different. However, considering that the topic and phenomenon is strongly technology based and therefore ever developing, the

interviewed person is seem to have enough experience that is based on current situation. The data that is gathered can be seen reliable and valid.

Before the conclusion of this research, some assumptions were made. The first assumption was that the facilities of the viewer are not the reason for live streaming problems. This assumption was made based on the experiences of the customers, who had not encountered any problems with other providers.

The second assumption was that the problem is not the insufficient Internet upload speed between the broadcaster and the server. The reason for this assumption is the high Internet upload speeds that are available in private sector and therefore also assumed to be available for businesses.

The third assumption was that the inadequate capacity of edge servers doesn't cause the live streaming problems. The reason for this assumption is the known amount of the maximum viewers which allows reacting accordingly with the edge server capacities.

The outcome of these is a theory of the problem that is most likely to cause the live streaming problems. Since the most probable reason was chosen and the other possibilities were eliminated by acceptable arguments, the theory can be seen reliable and valid.

7.3 Continuity of the study

> *"After reading the comments here and memorizing own experiences of the functionality of Ruutu+, Jatkoaika could publish an article of that topic. It is hardly beneficial for SM-Liiga itself if the TV-rights holder is unable to provide even reasonable content of the matches."*

This comment was posted into Jatkoaika on the 5th of May in 2014. Therefore it was posted well after the last official broadcast and demonstrates that the problem still exists.

This inductive study can be followed by deductive study that aims to prove the theory correct or incorrect. The following research can study the behavior of the routes and edge servers when exposed to the stress. During the study the edge servers should have put under stress but not simultaneously. The stress that is increased little by little would test the edge server capacity without exceeding the routes capacity. After the maximum capacity of the edge servers is revealed, the maximum amount of requests should be sent simultaneously and study whether the routes can take it or not. This particular research would prove the theory either correct or incorrect.

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